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Dynamic Masking: A Proposal of Burden-Based Metrics for Masking in K-12 Schools During the COVID-19 Pandemic

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ABSTRACT

BACKGROUND: Ongoing masking of K-12 children has not been universally accepted despite recommendation from public health authorities. In states without universal mask mandates for schools, district administrators are forced to make masking decisions under significant local political pressures. There is a call for endpoints to masking to allow communities to tailor mitigation while keeping schools safe, focusing on harm reduction.

METHODS: We reviewed existing measures for the safe opening of schools and designed a stepwise, accessible approach to the removal of masks in the K-12 setting.

RESULTS: Focusing first on the assessment of school impact due to COVID-19 disease and then considering the context of existing community transmission levels allows for a metrics-based approach to masking that is flexible and practical, enabling school officials to adapt quickly to the pandemic landscape in their communities, independent of political pressures.

CONCLUSIONS: While this proposal is preliminary, a dynamic metric system for masking may encourage those communities who wish to minimize masking to adopt masks during highest risk periods, protecting against SARS-CoV-2 transmission in schools and allowing for more holistic harm reduction. This approach may serve to guide districts during times of uncertainty when central guidance short of universal masking is lacking.

Keywords: schools; masking; disease mitigation; COVID-19; disease transmission.

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The decision over the requirement of masks for K-12 children in schools has been fraught with emotion[1] and controversy. The CDC's most recent recommendation for universal masking in schools has not eased tensions. School board members have received serious personal threats,[2] and school administrators, local officials, and clinicians are often targeted when in the public spotlight regarding such a heated issue. Health departments entered the COVID-19 pandemic understaffed,[3] and most directors must prioritize other responsibilities such as vaccination efforts over appearances at lengthy school board meetings.

Masking to prevent transmission of a communicable disease should not be politically controversial, yet history informs us otherwise. The use of masks can be traced to the bubonic plague in the Middle Ages. In the 1918 influenza pandemic, public health officials recommended masking to prevent the spread of disease, and many cities including Seattle, Denver, and Phoenix passed masking ordinances.[4] Newspapers from that time period reflect that while mask compliance was high in many areas, and there was apparent disease reduction in places where masking was required, there remained societal pushback. Some complained that masks were uncomfortable,

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[Correction added on 12 November 2021, after first online publication: Figure 2 has been corrected in this version.]

interfered with business, and were an infringement upon freedom, and San Francisco even saw the emergence of the ''Anti-Mask League.'' This resistance faded after the pandemic, and masks became a routine tool of the medical world. In the 1940s, surgeons adopted masking to prevent surgical fields from contamination,[5] and countries including China have used masks during disease outbreaks since SARS circulated in 2002.[6]

While we are still gathering data on the efficacy of masks, most data indicate that masking is an effective mitigation strategy for preventing SARS-CoV-2 spread,[7] particularly during higher levels of COVID-19 disease in the community. Since the start of the pandemic, numerous studies have revealed the benefits of masking in reducing the spread of SARS-CoV-2 by decreasing both respiratory droplet inhalation and exhalation.[8] It is also a fact that SARS-CoV-2 pandemic mitigations which include masking left the world with an unprecedentedly quiet influenza season in the winter of 2020-2021. Even common pediatric respiratory illnesses such as respiratory syncytial virus were low compared to pre-pandemic levels during the typical peak period.[9]

While masking has been used as a central mitigation strategy in schools, the emergence of the B.1.617.2 (Delta) variant of SARS-CoV-2 adds a level of uncertainty to the 2021-2022 school year. Delta is twice as infectious as previous variants, and the highest risk is among unvaccinated people who are most likely to acquire COVID-19 infection and transmit the virus. However, while breakthrough infections in vaccinated individuals are extremely unlikely to lead to their hospitalization or death, symptomatic vaccinated individuals can still spread the virus, albeit for a shorter period of time.[10] Therefore, CDC emphasizes the layering of mitigations with vaccinations for the prevention of COVID-19 disease spread. This approach was recently affirmed when 1020 Arizona schools were studied in July to August 2021: schools without mask requirements were 3.5 times more likely to experience COVID-19 outbreaks compared to schools with mask requirements in place.[11]

Children continue to have far less risk from COVID-19 infection than adults, but there is still risk to some children, especially those with underlying medical conditions. Multisystem Inflammatory Syndrome in Children (MIS-C) is a rare but serious inflammatory condition associated with COVID-19 infection, which may involve the heart, lungs, kidneys, brain, skin, eyes, and gastrointestinal system. As of August 22, 2021, there were 4661 cases of MIS-C in the United States since the start of the pandemic, with 41 associated deaths.[12] Myocarditis is another sequela of COVID-19 that we see in children, but it is very rare, accounting for 0.133% in those infected who are under 16 years of age.[13] Hospitalization of children with COVID-19 is infrequent, with approximately 0.1-1.9% of known cases resulting in the need for inpatient care.[14] However, a study of children who were hospitalized with COVID-19 found 22% had some degree of neurologic involvement with 2.5% of hospitalized children having life-threatening neurologic sequelae.[15] It is noteworthy that hospitalization rates have been found to be 10 times higher among unvaccinated than among fully vaccinated adolescents. Also, data indicate that rates of severe disease in hospitalized children were similar before and during the current period of Delta predominance which may suggest that the increase of children in hospitals is a reflection of increased total COVID-19 cases among children.[16] With the uncertainty of long-term effects of infection with SARS-CoV-2, the advent of the Delta variant, and the potential for other variants to arise in the future, it is imperative to have mitigation strategies such as masking available at times of high-community disease burden.

Freedom, Rights, and Dress Code: Heated Discussions in the Masking Debate

News stories across the country have depicted parents who feel that parental rights are being ignored where state officials have passed ordinances mandating masks for children in schools. This has led some states such as South Carolina and Tennessee to ban schools from having any mask mandate in the K-12 setting. Some districts, such as seen in northeast Texas, legally circumvented these mask mandate prohibitions by incorporating masks into the school dress code.[17]

The two sides of the masking debate are seemingly irreconcilable because individuals are not starting from the same shared beliefs, and school officials are left to try to moderate between the two sides. Many who oppose masking do not think that the health of their children is significantly endangered by COVID-19 exposure and feel strongly that their children need to see faces and avoid psychological downsides and potential discomfort of mask wearing. Many who support masking believe it is worthwhile because guidance and data suggest that it prevents children and others from becoming sick with COVID-19.

In the K-12 setting, unvaccinated individuals who are exposed to a person with COVID-19 during their infectious period are recommended by the CDC to quarantine for 14 days, ideally. Unique to the K-12 indoor setting, masked unvaccinated children who are 3 ft apart or more from a masked, infectious child do not have to quarantine because they are not deemed to be close contacts. This is a change in the CDC guidance from the 2020 to 2021 school year. However, if one of those children is unmasked, then children must be 6 ft apart to prevent being a close contact with a child infected with SARS-CoV-2. Most schools cannot meet 6 ft distancing, especially with more students returning

to in-person learning in the fall of 2021, which means an increase in close contacts and quarantining if some children are unmasked.

The requirement of exposed children to quarantine and the resulting negative consequences are key to consider when analyzing the freedom and parental rights arguments that arise around masking. Some individuals who do not recognize the benefits of masking may reason that their child's freedom is affected by a mask, and this is true. However, it is only a single freedom of that child that is affected, not overall freedom.[18] If an unmasked child is expressing their singular freedom to be without a mask, but this results in a masked child being forced to be quarantined for 14 days, overall freedom is lost. The quarantined child no longer has the freedom for in-person learning and the associated family may lose the freedom to earn a living during that time. From a rights perspective, the right of the parent to keep their child unmasked in school is infringing on the right of the masked child's parent to go to work.

As we know, community case rates and school case rates mirror each other.[19] As cases become lower in the community, there will be fewer COVID-19 cases coming into school and less risk of in-school SARS-CoV-2 transmission. Metrics aimed at safely removing masking requirements can reassure parents that the singular freedoms of their children are part of the overall district plan, while ensuring that the singular freedoms do not take precedence over all freedoms including the right of other children to avoid quarantine or illness from disease exposure and attend in-person school, as well as the right for parents to go to work.

Mask Mandates Across the Country

Some state governors have chosen to ''empower the localities''[20] to determine for themselves whether to require masks in schools, citing that COVID-19 has varied in its impact geographically,[21] as shown in Figure 1. As of September 5, 2021, mask mandates in schools are banned in 9.6% of states, such that local districts are not permitted to mandate masks. In 31.1% of states, local districts can determine their policy on masks in schools, because the state does not have mask mandates. In 17.5% of states, including Arkansas, Texas, and Florida, the statewide mask mandate ban has been overturned in legal proceedings, and some districts have then required masks. The remaining 41.8% of states have a statewide requirement for masking in schools.

A Need for Clarity

When COVID-19 cases began increasing in June 2021 with the circulation of the more contagious Delta variant,[22] the American Academy of Pediatrics (AAP) and the CDC[23] recommended masking for all K-12 schools indoors, regardless of vaccination status. However, the fact that they have not provided recommendations as to when masking requirements can be removed or fully accounted for the diversity of the country regarding vaccination rates, other mitigation measures, and case rates, has made many schools, communities, and parents frustrated. This has contributed to division between those who support masking in school and those who do not. Even policy think tanks, such as at Children's Hospital of Philadelphia, discuss the various scenarios when masks can be made optional or will be needed most, but do not offer clear on/off guidelines for masking.[24]

The CDC's failure to give schools timely opening guidance prior to fall of 2020 may contribute to the resistance of those currently against masking, because parents may be concerned that children will be masked indefinitely. In 2020, the CDC did not release back to school guidelines until August 26, 2020, weeks after many school districts had already been forced to make difficult decisions on re-opening. This delay caused many school districts throughout the country either to open very late in the 2020-2021 school year, or in some cases districts did not open at all. In acknowledging the primary importance of in-person schooling in its 2021 school guidance, the CDC has pivoted away from the idea that schools should be closed, given the lasting harms that were done to children last school year.[25] Yet, after the CDC delays in recommendations for the 2020-2021 school year, parents may understandably be concerned that guidance may not be timely as the pandemic continues to evolve. Some may fear that the blanket CDC recommendations for masking in schools may not allow for mask flexibility until as late in 2022. Also of concern is that a universal mask mandate regardless of underlying community-wide disease prevalence or immunization rates may fail to incentivize children and their guardians to get vaccinated. There needs to be an approach that is still driven by metrics and clear enough to be useful on a practical level to local decision makers. The following proposal outlines one possible approach to be considered.

METHODS

Dynamic Masking: A Burden-Based Model

Step 1: Start the school year masked. First, as recommended by the CDC[26] and the AAP,[27] it is scientifically reasonable to start the school year with universal masking for all students and staff at all grade levels. Other mitigation measures such as distancing or cohorting will likely be reduced compared to the 2020-2021 school year, as increased numbers of students will be present in buildings. Last year, in-school transmission levels were found to be low with multiple layers of mitigation in place; therefore, it makes sense to leave the simple mitigation of masking in place

Figure 1. **State Mask Mandates in Schools, 2021**

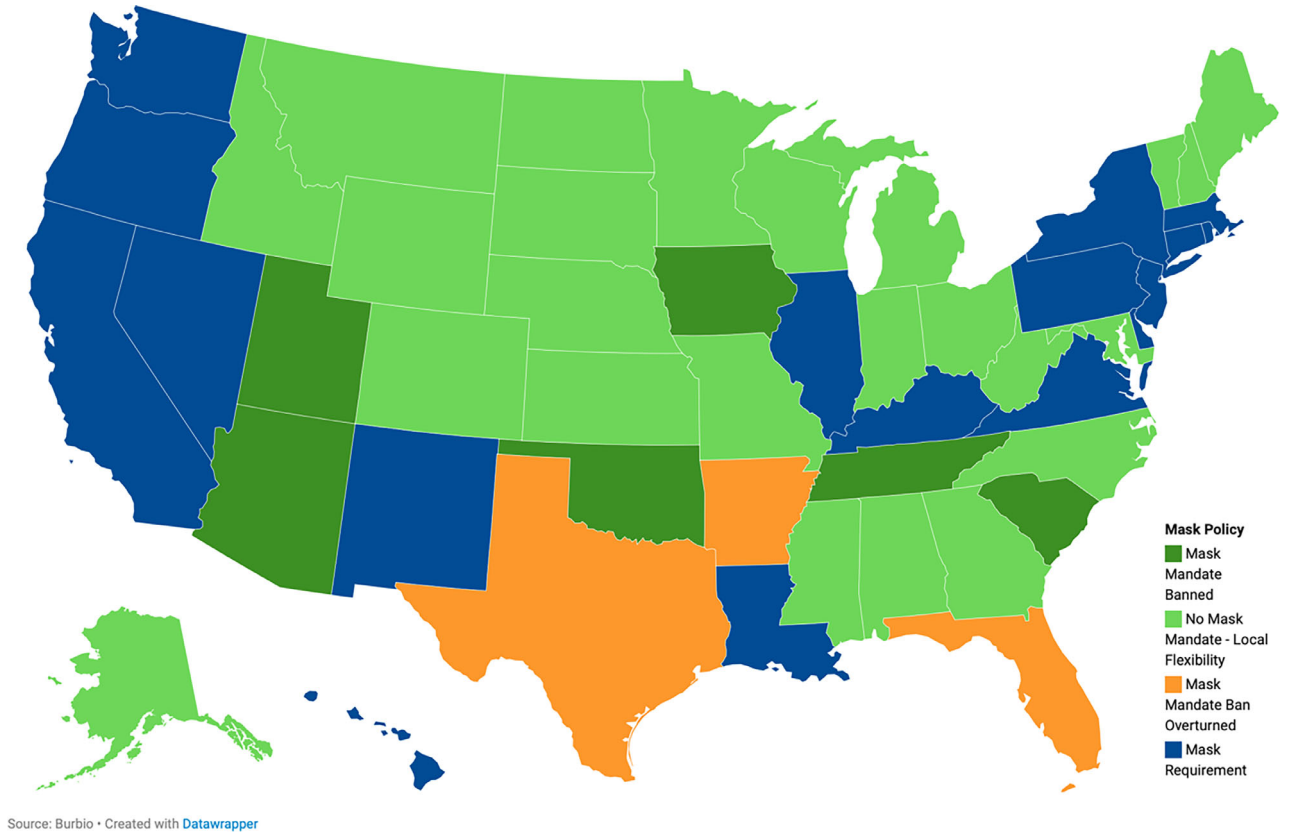

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Table 1. **Level of School Impact due to COVID-19 Disease**

	Level of School Impact*		
Criteria to Consider	**Low**	**Medium**	**High**
Transmission within school	Zero or sporadic cases with no evidence of transmission in school	Two outbreaks within a short time period or sporadic outbreaks in school. Size of outbreaks remains small	Several outbreaks in school within a short time period; size of outbreaks is large or scope of outbreaks is significant (eg, multiple classrooms or grade levels are impacted
Student absenteeism	At baseline/Low	Slightly above baseline	High
Staff capacity†	Normal	Strained	Critical

Reproduced with permission from the Virginia Department of Health. Available at: https://www.education.virginia.gov/media/governorvirginiagov/secretary-of-education/pdf/Interim-Guidance-for-COVID-19-Prevention-in-Virginia-PreK-12-Schools_July--21-2021.pdf Accessed August 1, 2021.
*Level of impact to school can only be assessed for those schools that have opened to in-person instruction.
†This subjective assessment should factor In a school's ability to maintain adequate staff for facility operations, transportation, teaching, and administrative functions, it should include input from teachers/staff regarding their availability to provide in-person Instruction.

to start the year. More importantly, the fact that the more contagious Delta variant is the dominant strain of SARS-CoV-2 should be considered in the decision to universally mask in schools to start the year.

Step 2: Assess school burden. After a period of 4 weeks of universal masking for all schools regardless of the community level of SARS-CoV-2 transmission, district officials could consider the implementation of mask-optional policies. The first step in considering the removal of masks as mitigation would be to evaluate school burden, understood as low, medium, or high impact, as shown in Table 1. This impact classification tool is available from the Virginia Department of Health. School impact, or burden, can be best understood by examining school transmission, student absenteeism, and staff capacity. If the impact

Table 2. **Dynamic Masking: Proposal for Masking Metrics, According to Age and Community Disease Spread, During Low School Impact**

	Low Transmission*	Moderate Transmission	Substantial Transmission	High Transmission
Students ≥12 years	Mask optional	Mask optional	Mask optional for all when ≥80% vaccinated	Universal masking
Students <12 years	Mask optional	Mask optional	Universal masking	Universal masking
School staff	Mask optional	Masking if no vaccination	Masking if no vaccination or unknown vaccination status	Universal masking

*Levels of community transmission defined by the CDC as total new cases per 100,000 persons in the past 7 days (low, 0-9; moderate 10-49; substantial, 50-99; high, ≥100) and percentage of SARS-CoV-2 positive tests in the past 7 days (low, <5%; moderate, 5-7.9%; substantial, 8-9.9%; high, ≥10%).

of SARS-CoV-2 on a school is low, then administrators could proceed to Table 2, which considers community disease transmission, to determine if the timing is appropriate for the removal of masks for a 4-week period. During this mask optional period, school impact must be monitored closely. If school impact rises to medium or high levels (Table 1), then masking should be reinstituted for 4 weeks, awaiting a decline in school impact. It is imperative that contact tracing is adequately performed, and health officials are assisting with monitoring transmission and impact, or burden, within the school.

Step 3: Consider community transmission levels. The CDC uses the term ''community transmission'' to describe how much spread of SARS-CoV-2 is occurring in a region. This metric is based on new cases arising in 7 days per 100,000 residents, and test positivity, the percentage of positive tests for SARS-CoV-2 among the total number of tests performed, averaged over 7 days. The level of community transmission is classified as low, moderate, substantial, or high based on total new cases per 100,000 persons in the past 7 days (low, 0-9; moderate, 10-49; substantial, 50-99, high, ≥100) and test positivity in the past 7 days (low, <5%; moderate, 5-7.9%; substantial, 8-9.9%; high, ≥10%). Administrators can easily view their overall community transmission status via the CDC website[28] which is displayed in a color-coded map.

Moreover, data obtained over the 2020-2021 school year, before the Delta variant, showed that school case rates mirror community case rates.[29] If more students are entering schools during their SARS-CoV-2 infectious period, there will be more students who must be placed in quarantine, particularly among <12-year-old students who have not been able to be fully vaccinated. As shown in Table 2, if community transmission is high, we propose that schools require universal masking as a layered mitigation strategy given how many children are likely to come into the school, raising the risk of in-school transmission. If community transmission is substantial, consideration may be given to being mask-optional for those ≥12 years if school impact is low when vaccination rate among students is ≥80%. If community transmission drops to low or moderate, masking may be made optional as delineated in Table 2, with careful monitoring of school impact.

DISCUSSION

Use of this proposed dynamic, burden-based masking model may prevent extensive outbreaks by tailoring mitigation to a community's needs beyond what is provided by the CDC. In August 2021, many Mississippi schools[30] were forced to re-institute masking after multiple outbreaks occurred in unmasked schools, resulting in extensive quarantines, and in-school transmission. Having a start and stop point for masking may be more accepted by areas reluctant to adopt a long-term universal masking policy. Given the duration of the pandemic, our focus should be on the development and utilization of flexible harm reduction strategies, recognizing that all disease mitigation strategies have downsides.

Our dynamic masking metric proposal leans on school burden or ''school impact,'' which can vary greatly within a district. This could be perceived as an advantage as these metrics allow a school-by-school approach to the use of masks. This can subsequently aid more diverse, large districts where individual schools may have variability in vaccination rates, ability to mitigate with distancing, and numbers of infected children coming into the school. For instance, if one school has 80% of its staff and children vaccinated, whereas another school elsewhere in the district has only has a 40% vaccination rate, there could be medium or high school impact in the latter school such that a decision could be made, using our proposed metrics, to keep masking in this school while allowing the other school to remove masks.

While monitoring of school impact and community transmission levels is important for knowing what mitigation is needed, vaccination remains vital to the reduction of SARS-CoV-2 spread and disease severity. We do not know to what extent vaccinated, *asymptomatic* individuals can transmit SARS-CoV-2 but this type of transmission is felt to be low. Therefore, per the CDC, vaccinated individuals without symptoms do not have to quarantine after exposure, thus reducing impact on a school beyond decreased transmission. As of July 2021, the CDC added a recommendation that fully vaccinated individuals who have a known exposure to someone with suspected or confirmed COVID-19 should be tested 3-5 days after exposure and wear a mask in public indoor settings for 14 days

or until a negative test is obtained, but even after this change, such individuals could still attend school. Vaccinations remain crucial to decisions regarding universal mitigations, and every legal effort should be made for schools to have vaccine records on file for all students and staff. Some schools are leaning on vaccination rates exclusively to determine masking status in schools. For instance, in Massachusetts, masking is optional for those vaccinated staff and students ≥12 when more than 80% of the staff and student body is vaccinated.[31]

Unfortunately, it is not always easy for schools to obtain COVID-19 vaccination status of students and staff.[32] Private schools and colleges may require vaccination or mandate reporting of vaccination status; however, the path is not always clear with public schools given that COVID-19 vaccination is not required by law in most places. In Virginia, for instance, school health officials are allowed to access a student's state immunization record system only for the purposes of making sure a student has vaccines that are required by the state and for determining medical decisions and mitigations such as quarantine that would directly impact a student's health.[33] Federal guidelines surrounding HIPAA (Health Insurance Portability and Accountability Act) that cover health providers and FERPA (Family Educational Rights and Privacy Act) that regulates educational records are not clear regarding schools' ability to legally request vaccination data from students and staff. We recommend districts rely on their legal counsel for determining if and how they may access vaccination records.

Some have suggested that hospitalization rates should be considered as a metric for masking.[34] While this is a useful metric for masking mandates on a community level, this approach does not work as well for the school setting. Hospitalizations could remain low if the most high-risk individuals in a community are vaccinated fully, but school impact could be high due to cases in schools where children are largely unvaccinated. Utilizing low hospitalization rates to end masking does not necessarily account for the potential of high numbers of COVID-19 cases coming into schools, which may cause excessive quarantine and absences. We also know that hospitalization rates tend to lag behind case counts. In the interest of keeping as many children healthy and physically in school as much as possible, community transmission is a more appropriate secondary point for masking decisions for a school district.

Limitations

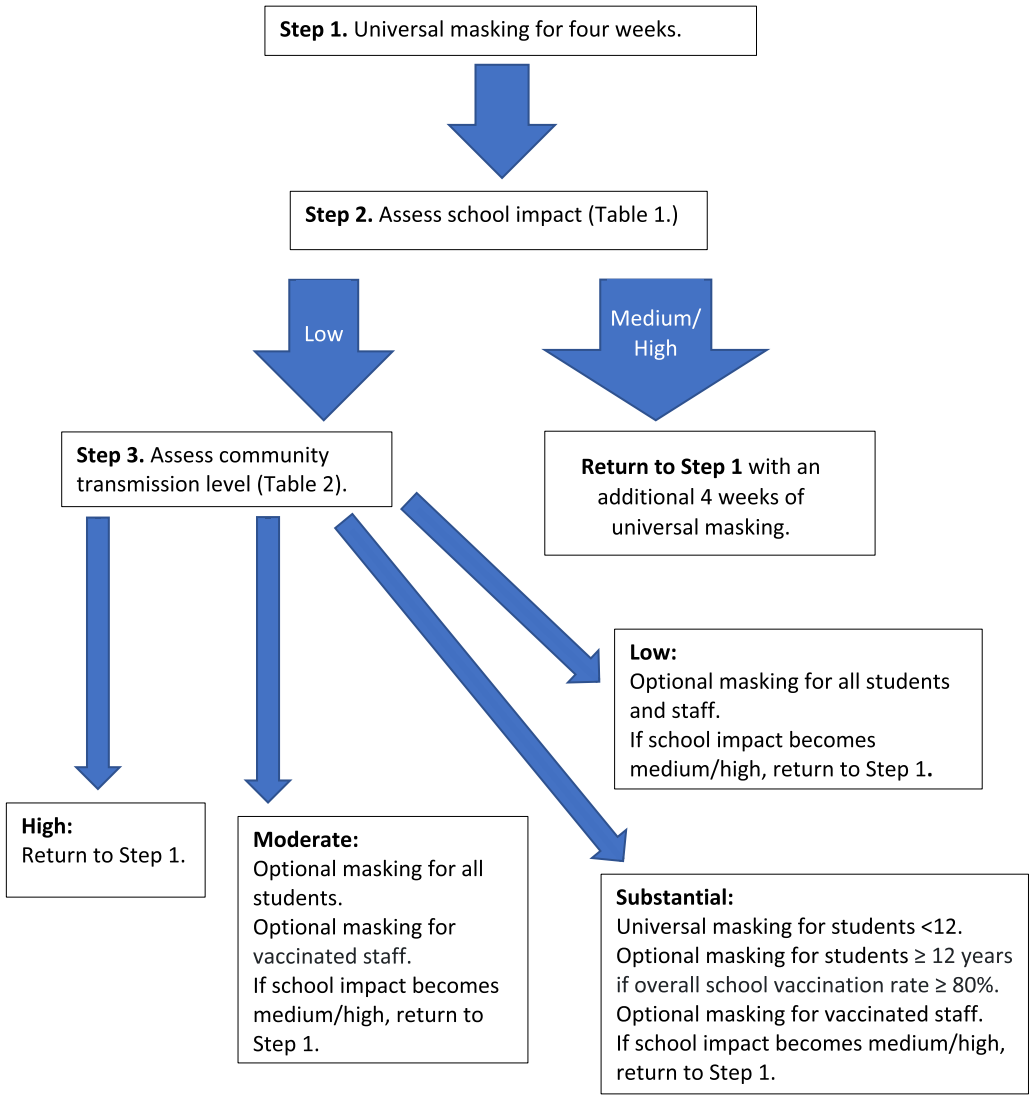
The dynamic masking model has not yet been tested and if adopted on a trial basis by districts, associated metrics may need to be modified. For instance, if it becomes clear that removing masks among K-12 children during times of moderate transmission results in immediate progression to elevated school impact, then metric cutoffs for masking should be readjusted. This could occur due to Delta, for which we are still gathering transmission data in schools, or there could be a new variant of SARS-CoV-2 that results in greater morbidity and mortality in children or is not covered as well by vaccination. While we hope this does not occur, it is possible that our dynamic model, with a ''peeling the layer of masking,'' could be preserved, if districts use school impact as well as community transmission as a guide to masking as a mitigation measure.

The possible variation of school impact within a district may make it challenging for administrators to decide when to remove masks for an entire district. If there is variability in absenteeism, transmission, and staffing among schools each school may need to make individual decisions rather than district-wide decisions. As described previously, this could be advantageous in that individual school-by-school decisions may be needed in large diverse districts where other variables such as vaccination rates may differ significantly from school to school. Additionally, if a school has students who are less than 12 years old who come in frequent contact with those ≥12 years, such as a grade 5-8 middle school, administrators may wish to implement masking for the entire building during times of substantial transmission.

The dynamic masking model described uses CDC metrics to determine community transmission which also has some limitations. The CDC determines percent positivity and total cases in the community from data reported from health departments. If this reporting is delayed, the community levels as reported may also be delayed. In addition, those who are asymptomatic are less likely to seek testing and those who do a home test are less likely to report results, both of which could affect percent positivity rates for the community. While numerous studies[19,35] have provided strong evidence that transmission of SARS-CoV-2 in schools are reflective of transmission within the community, these studies were done prior to the Delta variant. This same data will need to be closely followed as we enter the 2021-2022 school year with the Delta variant as the predominant strain.

The dynamic masking proposal described has an option during substantial transmission to allow optional masking of children aged 12 and older when the school vaccination rate is >80%. Ideally, schools could permit vaccinated students to be mask optional in these conditions, but this would force teachers and staff to monitor individual students and track each student's vaccination status which is not feasible. The described metrics will need to be revisited when vaccinations are available for children <12 and by individual states and districts if decisions

Figure 2. **Dynamic Masking: A Burden-Based Masking Model**



are made to require COVID-19 vaccination for K-12 enrollment as has occurred in some college and university settings. At that time, it may be reasonable to treat all K-12 students with a single approach with masking.

Time will tell if COVID-19 vaccinations will stand the test of new variants. However, these proposed dynamic masking metrics account for these changes by relying on community transmission and school impact rather than vaccination status alone.

IMPLICATIONS FOR SCHOOL HEALTH POLICY

Schools without a state-level mandate can consider the proposed dynamic masking metrics when desiring a clear data-driven approach to masking as mitigation in the K-12 setting. We suggest considering the approach described in Figure 2.

Masking should not detract society from focusing on what is most crucial: children should attend full, in-person school, for as many days as possible. Schools must consider how to reduce quarantine and keep students in the classroom. The CDC now allows children who are masked and 3 ft apart in school to avoid quarantine.[36] While voices who oppose masking sometimes cite the fact that few children are hospitalized with COVID-19,[37] it remains true that acquiring COVID-19 disease, even if it is a benign illness to that particular child, will result in school absence for that child and potentially close contacts. It is therefore without question that districts must focus on implementing measures to keep as many children in full-time school as possible and this includes masking during times that it is most needed.

Human Subjects Approval Statement

Preparation of this paper did not involve primary research or data collection involving human subjects, and therefore, no institutional review board examination or approval was required.

Conflict of Interest

All authors of this article declare they have no conflicts of interest.

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